BACKGROUND OF THE INVENTION

The problem of the high specific weight of accumulators, fuel cells and electrolyzers arises from the use of heavy metal electrodes, such as lead, silver, zinc, platinum, etc. These metals have very high densities and low mechanical strengths. Discharge depth is limited by electrode strength since active materials also have a structural function in electrodes.

These metals also have high active surface areas. A specific surface area of special electrodes such as porous electrodes or slurry or powder electrodes, is advantageous and may be used with or without a catalytic plate.

Some electrode pairs, such as zinc - silver, also have dendrite problems. As a result, dendrite induced short circuits limit the number of cycles during the life of a rechargeable battery.

An object of this invention is to decrease the weight and increase the strength of accumulator, fuel cell and electrolyzer electrodes. A design using carbon paper is described in U.S. Patent 4,894,355 which proposes to decrease the active surface area by cutting the ends of the fibers which consist of a carbon paper/polytetraflouroethylene composition. In this case, the main load of design takes carbon carrier material - paper, and conductivity parameters, determines thickness and span of electrode.

SUMMARY OF THE INVENTION

One object of this invention is to combine in one unit conductivity or insulation parameters with a high strength/low weight ratio. Active and/or catalytic materials may be used in plate (catalytic fuel cell or electrolyser) or in friable form (accumulator). Friable materials permit a better use of the chemically active material without weakening the electrode's structure. The efficiency of the electrodes is increased as a result of enhanced intergranular contact induced by an external or internal spring or spring-like element and/or by the battery's outer casing. The invention unifies these parameters and as a result there is a decrease in weight per discharged energy.

According to the invention, the battery cell comprises an external or internal flexible envelope or flat layer in which a flat, electrically conductive, flexible wire or fabric grid is embedded in a matrix of granular or powder particles of an active material. Another envelope is also present containing an electrically conducting wire or fabric grid on which grains or particles of a complementary active metal or compound are positioned. The envelopes are separated by an insulating membrane which is permeable to the ions of a suitable electrolyte. There are conductive leads from each of the battery's cells. There is also a flexible mechanical spring or electrolyte swelling element that supplies the required pressure to counteract the electrode's volume changes resulting from the chemical reaction in the cell.

The active material can be placed in a membrane bag or between sheets. The grains of active material can be fixed in position as distinct units by welding the cover.

The present invention provides a means for applying pressure to the external surface of the assembled cell, ensuring close contact between the granular or powder particles and between the particles and the electrode during charging and discharging. This contact is maintained despite significant volume changes of the active material during the reaction.

Various pairs of metals or compounds can be used, such as Ag/Zn, Pb/PbO, etc.

The electrodes can be fabricated in the form of lengthy ribbons which are then rolled into a spiral configuration. In such a design, it is advantageous to provide a spring or spring-like means to apply pressure to the external surface of the electrodes and to fabricate the cells in cylindrical form.

The spring or spring-like element may be an entirely separate element included in the battery or associated with a swelling separator. Alternatively, the flexibility of the battery cell's walls can function as the spring element. A separate spring element is best suited for flat batteries where cell wall height is limited. The side walls of the cell are best suited to serve as the spring element when the cell has a cubic, or at least rectangular, shape. Flexible outer cylindrical containers can function as the spring element for cells with helical electrodes.

The powder or grains of the active material are preferably in the 5 to 10 micron range, although other sizes can be used.

The sheet grids may be made from expanded metals, such as silver (for Ag-Zn element). These are manufactured from expanded metal foil relevant to the active material of the cathode or anode. Conductive fabric thickness is generally about 10 μ to 500 μ, with a preferable thickness being about 100 μ. The fabric can be woven from carbon fibers. Conductive materials may be coated with suitable metals, the exact metal depending on the nature of the electrochemical couple in the cell and the environment in which the cell operates.

For multicell versions, the conductive thread may also be used in combination with non-conductive fibers. In such conductive fabrics, a plurality of parallel carbon fibers interwoven with fibers of Kevlar, nylon, polyester, etc. can be used. The configuration may be one in which each carbon fiber constitutes an electrode. It is clear that the carbon fibers must be connected and a conductor lead provided for the current output.

A modification of the invention based on the same concept comprises fuel cells in which each membrane bag contains catalyst particles preferably attached to a suitable support. The catalyst may be in the form of ceramic particles coated with an active material, such as Ni, Pt or Cd. A suitable acid can serve as a catalyst in the fuel cell with oxygen and hydrogen reacting to form water and produce electric current. Suitable electrode connections are provided for current uptake. In the case of fuel cells, no external pressure on the cell is required. A catalyst may be directly plated on the carbon fibers increasing the active surface area.

Due to the thin elements of the electrochemical cells, the weight to power output ratio is improved. Since the main elements of the cells are a conductive fabric, granular active material, suitable membranes and an electrolyte, the cells can withstand extreme accelerations and decelerations without detrimental effect on cell performance.

A high energy, high speed chargeable battery cell can be produced when provided in a helical configuration.

According to this invention, electrodes, connection elements and cell walls are made from high-strength, conductive or insulative fibers/fabrics, catalyst, and active material in plate or friable form or the like. Carbon fibers may be used as the conductive part of electrodes while for the insulative parts, nylon, polyester, Kevlar or glass fibers can be used. The exact choice of insulative material depends on the electrolyte chosen.

Different designs can be used depending on the electrochemical principles. Parts should be designed to obtain stable electrical contact, resulting in conductivity in friable forms of the active material. Similarly, there should be adequate contact between the active material and the current input-output elements.

Suitable designs can include:

1. Electrodes, insulation elements, spring and outer cell casing made from separate parts and assembled into a single unit.

2. Electrodes and insulation elements in one unit. One piece of fabric woven in accordance with the need for the combination of conductivity and insulation or conductivity, insulation and active materials.

Different electrolytic principles of accumulator design may be realized using the first design.

Determination of some of the parameters suggests the following design specifications: a fiber thickness of 10 μ, a fabric thickness of 0.05, a specific area for the electrode of 31.5 cm^2 per cm^2 of electrode geometry area. This is without any special surface treatment to increase the microsurface.

The active area per unit weight in this case is 1875 cm^2/g about 1100 times greater than a solid surface.

Additional specifications include conductivity cross-section per span distance, 0.0157 cm^2/cm, electrical resistance, 0.4 - 0.5 ohm*mm^2, and a permissible stress of 50 kg/mm^2 given a fabric density of 168 g/m^2 i.e. a maximum destroying length of 30 km. In comparison, lead has a value of 0.122 km, zinc 0.63 km and copper 2.263 km. Therefore, a coated graphite fiber electrode can withstand acceleration 15 times greater than a copper electrode and 300 times greater than a lead electrode for electrodes of equal lengths.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a sectional view of the configuration of an accumulator of the Zn -Air or Zn- Ag type with anodes of the Zn – ZnO, and cathodes of the-Ag-Ag20~~Zn –~~ AgO ~~or Ag – ZnO~~ slurry type.

~~Figure 2 is a sectional view~~ Figures 2A and 2B are views of the design of a Zn-Air accumulator cell or one with Zn - Ag pairs with anodes of the Zn – ZnO, and cathodes of the- Ag-Ag20 ~~Zn –~~ AgO ~~or Ag – ZnO~~ slurry type.

Figure 3 is a sectional view of a spiral design for an electrode couple.

Figure 4 illustrates a parallel or serial connection between cells.

Figure 5 illustrates a multicell, one-piece design of a special fabric.

Figure 6 illustrates multi-electrodes and multicells made from one piece of special fabric.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

Reference is now made to Fig. 1. Figure 1 is a sectional view of an example of a unit cell of fabric with central coaxially displaced conductive fabric elements.

Electrode conductive element 1 (cathode or anode) is a woven carbon fiber fabric. In this case, the fibers do not need special treatment to increase their microsurface.

~~Electrode housing 6~~ The device has a flat piece of conductive grid or fabric 1 inserted into ~~electrical insulation~~electrode bag ~~5~~ 3 filled with a zinc, lead or silver oxide slurry 2 on both sides of conductive element 1.

The electrode ~~bag 6~~bags 3 and both layers of slurry 2 are pressed together by a spring 4 and intake are in separate insulation chamber 5 made from electrolyte permeable insulating fabrics which represents an accumulator element.

Reference is now made to Fig. 2. ~~Figure 2 is a sectional view~~Figures 2A and 2B are views of a design of a unit cell of fabric. Electrode conductor ~~1~~ 201 (cathode or anode) is woven from carbon fibers. Again, the fibers do not require special treatment to increase their surface area.

Electrode conductor ~~1~~ 201 is made from a zinc, lead or silver oxide slurry ~~2~~202.

Electrode bag ~~1~~ 203 can be provided with lattice or diagonal seams ~~7~~ 207 to prevent agglomeration of the slurry powder 202 into a single piece. This helps to ensure an adequate powder distribution on the electrode surface 201. The

electrode ~~bag and both intakes~~bags 203 are in separate insulation chambers ~~3 made of electrolyte permeable insulating fabrics~~204.

The insulation chamber~~s~~ 204 may be changed and divided into pieces of fabrics, which may be sewn to form an electrode bag from the sides of a pair of electrodes. The sewing threads may be made of insulating material.

A couple of these insulated electrodes (cathode and anode) have one difference: the consistency of slurry ~~2~~202. In an accumulator design, the electrode pair or set of electrode pairs may be held under pressure by spring elements ~~8~~ 204 of a different form. This saves the pressure needed for electrical contact between slurry and conductive fabric and between separate slurry nucleus (about 0.5 kg/cm^2). However, this pressure supply needs structural integrity.

The electrode couple is located in a common shell ~~4~~ 205 and constitutes a single cell. Shell ~~4~~ 205 may be produced from flexible or rigid plastic materials like polyethylene, polypropylene, polyurethane or PVC. This material may be reinforced with glass, polyester, Kevlar, etc. fibers. The connection of all elements into a single unit may be effected by heat welding at ~~5~~seal 208. The free electrode ends ~~6~~ 206 may be used for the electrical connection of the cell.

The shape of the electrode and its position in a battery cell may vary. Among the various alternatives which can be used in a plate electrode with trim placing or a circular electrode in a coaxial structure. Electrolyte may be stored permanently in shell ~~4~~ 205 or supplied periodically by special welding tubes.

Figure 3 is a sectional view of a spiral design for electrodes. A pair of flexible electrodes ~~1~~ 301 and ~~2~~ 302 of the form shown in Figs. 1 or 2 are rolled

into a spiral and inserted into an elastic sleeve ~~3~~303, the latter serving as a spring element to ensure adequate contact pressure (0.2 kg/cm^2). The rolled spiral with spring elements is inserted into outer housing ~~4~~304. In some embodiments, the swelling separator and outer housing may also serve as the spring elements.

Figure 4 illustrates a connection ~~3~~ 403 between cells ~~1~~ 401 and ~~2~~ 402 with the cells connected serially or in parallel. Some electrode bags which are meant to be connected can be made from a single piece of conductive fabric. In such a case, all conventional connecting parts are excluded, decreasing accumulator weight and complexity and increasing reliability.

Figure 5 illustrates a one piece multi-electrode design which consists of a special fiber combination with a trim conductivity 503 and insulation fiber or group of fibers 502, for use as electrode insulation or connecting elements. This trim may be different for weft and warp, for different accumulator designs, or because of weave problems.

The one-piece multi-electrode design includes a conductive part of electrode ~~1~~ 501 and 503 made from conductive fibers and an insulative part ~~2~~ 502 made of insulative fibers. Conductive parts of fabrics may also be used in conjunction with cross conductive thread stripes, which can connect electrode parts.

For a better connection between electrode parts 503 and the connection strip 501, the connection may be preliminarily plated and welded.

The trim of conductive parts does not determine what kind of electrode (cathode or anode) may be connected and what type of connection, parallel or series, should be used.

These parameters may be chosen as in common battery designs, where a one piece multi-electrode fabric is a common element that pérmits different designs and electrical configurations of accumulators, fuel cells, or electrolyzers.

The fabric can be coated on one side with PVC, polyethylene, polypropylene or polyurethane, for welding with other layers of the design, and outer shell formation. In such a case, the conductive fibers must be first treated to permit adhesion to the coating material.

~~Figure 6 illustrates a design that can be realized with a multi-electrode one piece fabric. This design is an example of a slurry electrode accumulator with serial connection of separate cells. The design consists of two one-piece multi-electrode units 1, separated by an electrolyte permeable fabric 2 that can be sewn or welded separately from the electrode design piece.~~

~~The welding seams position is in a form that provides insulation of separate cells formation with intake and outlet channels if a flow electrolyte system is used and permeability of outer space.~~

EXAMPLES

Example #1

Battery layout	Flat
Battery active material	Silver - Zinc

Number of cells in battery	2
Battery voltage	3 volt
Battery capacity	5 Ah
Battery housing thickness	5.4 mm
Battery housing area	18.5 cm^2
Electrode particle diameter	0.005-0.01mm
Silver electrode thickness	0.8 mm
Zinc electrode thickness	0.92 mm
Silver weight	19.45g
Zinc weight	11.78g
Weight of total active material	31.23g
Weight of conductive material	1.90g
Weight of insulation material	1.64g
Weight of electrolyte, KOH	21.4g
Weight of accessories	37.1g
Total weight of battery	88.77g

<u>Example #2</u>

Battery layout	Flat
Active material	Silver - Zinc
Number of cells per battery	16
Battery voltage	24 volt
Battery capacity	100 Ah
Battery housing thickness	200mm

Battery housing area	200 cm^2
Electrode particle diameter	0.005-0.01 mm
Silver electrode thickness	0.8 mm
Zinc electrode thickness	0.92 mm
Silver weight	3169g
Zinc oxide weight	2023g
Weight of total active material	5192g
Weight of conductive material	93.5g
Weight of insulation material	215g
Weight of electrolyte, KOH	2545 g
Weight of accessories	765g
Total weight of battery	8810 g

<u>Example #3</u>

Battery layout	Flat
Battery active material	Lead
Number of cells in battery	6
Battery voltage	12 volt
Battery capacity	60 Ah
Battery housing thickness	150 mm
Battery housing area	120cm^2
Electrode particle diameter	0.005-0.01mm
Anode thickness	0.8 mm
Cathode thickness	0.92 mm

Lead weight	6,300g
Lead oxide weight	7,100g
Weight of total active material	13,400g
Weight of conductive material	421g
Weight of insulation material	85g
Weight of electrolyte, acid	1110g
Weight of accessories	521g
Total weight of battery	15,452g

<u>Example #4</u>

Battery layout	Spiral
Battery active material design	Silver - Zinc
Number of cells in battery	1
Battery voltage	1.5-1.8 volt
Battery capacity	15 Ah
Battery spiral diameter	30mm
Battery spiral height	27mm
Electrode particle diameter	0.01 mm
Silver electrode thickness	0.8 mm
Zinc electrode thickness	0.92 mm
Silver weight	45.32g
Zinc weight	11.78g
Weight of total active material	57.1 g
Weight of conductive material	1.90g

Weight of insulation material	1.64g
Weight of electrolyte, KOH	28.9g
Weight of accessories	19.5g
Total weight of battery	109.04g